Appendix A
THE FOUR STEPS IN DETAIL

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Step 1: Define the Problem

Step 1A: Preliminary Analysis

The measures outlined below are recommended as a starting point. The initial assumptions, estimates, and information collected may be informal, but as the endeavor proceeds to subsequent steps, the information should be improved.

Determine the probability of damaging earthquakes and determine whether it is significant enough to justify further action.

Request a formal statement on seismic risk from the U.S. Geological Survey (USGS), a state geological agency, a university professor of seismology, or a consulting seismologist or risk analyst.

Locate a map that depicts the location of faults and the intensity of ground shaking associated with an earthquake. The USGS, a state geological survey, FEMA, and other organizations have these maps or can help locate them.

Establish criteria, types of buildings considered to be unacceptably vulnerable, and survey the building stock. Useful assistance may be found in the following FEMA publications: Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook and Supporting Documentation (FEMA 154 and 155) and the NEHRP Handbook of Techniques for the Seismic Rehabilitation of Existing Buildings (FEMA 172). The Applied Technology Council (ATC) of Redwood City, California, also has available Evaluating the Seismic Resistance of Existing Buildings (ATC-14).

- Request a formal statement on the vulnerability of the types of buildings in the jurisdiction from a qualified structural engineer or organization, university professor, state agency, or consulting structural engineer.
- Secure photographs or slides showing the effects of earthquakes characterized by probable ground motions on buildings like those under consideration. USGS, FEMA, the Earthquake Engineering Research Institute (EERI), and earthquake professionals can provide these.
- Collect data on the building stock and identify the types (structural systems, number of floors, date of construction), numbers, and locations of buildings considered vulnerable. Initially this information may be a general description based on informed judgment.
- Collect property tax assessment data identifying building characteristics, square footage, values, and owner names and addresses.
- Collect occupancy and use information for each building.
- Identify buildings in which hazardous materials are used or stored.

Anticipate uncertainty in expert knowledge as well as disagreements among experts, but work to eliminate the appearance of significant disagreement among credible scientists and engineers by seeking consensus on the most significant points.

Encourage scientists and engineers to debate differences among themselves, ignore minor differences, and publicly air only those disagreements that bear significantly on the policy decisions to be made. Policy-makers with generalist backgrounds should not be expected to resolve technical disagreements, but they can be expected to delay action when seemingly equally qualified scientists and engineers disagree among themselves.

Arising early in Step 1A is the question of the types of buildings considered to be earthquake-vulnerable. Following is a comprehensive list of suspect building types based on earthquake experience and research:

- Unreinforced masonry bearing wall buildings
- Tilt-up concrete wall buildings
- Reinforced masonry wall buildings
- Nonductile concrete moment resisting frame buildings
- Wood frame buildings with soft stories and inadequate foundation connections
- Moment resisting steel frame buildings
- Buildings in areas of expected ground failure
- Earthquake-vulnerable essential buildings

The following profile of typical building uses should be viewed in conjunction with the above list:

- Schools
- Churches
- Hospitals
- Government offices
- Essential services (fire, police, emergency operations, communications, and coordination centers)
- Nonessential services (planning, park and recreation)
- Parking structures
- Residential
- Office/commercial
- Retail
- Manufacturing
- Warehouse
- Industrial
- Public assembly
- Theaters
- Arenas
- Mixed uses

The following outlines various impacts, positive as well as negative, of seismic rehabilitation:

- Lives saved and injuries prevented
- Businesses and homes saved from future damage
- Business and residential disruption prevented
- Increased owner debt and higher loan service payments avoided
- Changed property values and tax levies
- Increased rents
- Some buildings demolished or vacated
- Historic buildings protected
- Other code upgrades triggered (disabled access, energy conservation, asbestos removal, fire sprinkler installation)
- Changed property and other insurance premiums
- Altered availability of loans and insurance

For the affected buildings and neighborhoods, collect data on or at least estimate: the numbers, ages, income levels, ethnicity, and language capabilities of residents; the numbers and types of businesses and associated employees; the ownership patterns (resident or absent, multiple property and large building owners, government agencies, nonprofit organizations, condominium associations); the property values, loan to equity ratios, mortgage default rates, and rental rates; and the applicable occupancy levels and vacancy rates.

Evaluate economic data on: the range of costs to rehabilitate typical buildings (for various performance levels) based on structure type, local seismic hazard, and size; the time required to rehabilitate individual building types as well as the whole target set; the potential indirect costs due to the disturbance and displacement caused by the rehabilitation work (lost rent, lost businesses, lost tenants, cost of relocating and inconvenience, and lost sales and property tax revenues); and the future financial benefits of reduced damage.

Many private consulting firms have computer programs and the expertise needed to estimate potential earthquake losses for individual buildings, a portfolio of buildings at different locations, or all buildings within a geographical area. In addition, the National Institute for Building Sciences (NIBS) has released, nonproprietary software ("HAZUS") developed for FEMA that anyone with a desktop computer can use to estimate earthquake losses for their geographic areas.

While data on nationwide earthquake hazards and building stock information from the 1990 census and other data bases will provide at least a general perspective, local information such as that collected as part of this approach can be added and will allow for more accurate planning. Consider using the NIBS software or hiring a firm to use a proprietary program.

Review the results of this preliminary analysis and decide if the seismic risk to the community, company, or owner is significant enough to proceed to the more detailed analysis described in Step 1B.

If the decision is to proceed, prepare a rough estimate of the cost and a schedule to adopt and implement a seismic rehabilitation program.

Step 1B. Detailed Analysis

The information, assumptions, and estimates made in Step 1A should be revisited and additional detail on those points should be sought as part of Step 1B.

Set preliminary earthquake risk reduction objectives: Which buildings? What priorities? What pace? What levels of performance? The following summarizes the performance levels (from greater to lesser) discussed in Chapter 1 of the *Guidelines* and volume:

- Collapse Prevention: means that limiting post-earthquake damage state in which the building is on the verge of experiencing partial or total collapse.
- Life Safety: means that post-earthquake damage state in which significant damage to the structure has occurred, but some margin against either total or partial collapse remains.
- Immediate Occupancy: means that post-earthquake damage state in which only limited structural and nonstructural damage has occurred.
- Operational: means that post-earthquake damage state in which the building is suitable for its normal occupancy and use, albeit possibly in a slightly impaired mode.

Performance levels should be matched with building types and functions to determine priorities and pace. In addition, Figure A1 is reproduced here from the *Guidelines* to remind the user of the process for selecting a seismic rehabilitation strategy for a specific building.

Review existing policies, goals, objectives, and requirements in the community to determine how they may "dovetail" or conflict with proposed earthquake risk reduction strategies including land use, economic development, housing, historic preservation, aesthetic and environmental, planned uses for affected areas, future conformance with zoning ordinances, planned changes to infrastructure, compliance with Americans with Disabilities Act (ADA) and other code mandates, compliance with storage and use of hazardous materials regulations, emergency response roles and capabilities, and any other applicable goals, objectives and requirements.

Identify and map hazard areas and affected neighborhoods. Existing maps can be used to identify areas of potential liquefaction and other ground failure as well as areas underlain by soft or saturated soils, including fills over lake and river beds and bay deposits.

Identify neighborhoods or areas where earthquake-vulnerable buildings are highly concentrated.

Consult with the local emergency services manager, fire and police chiefs, and directors of planning, redevelopment, and public works to determine the capability and plans for post-earthquake fire suppression, search and rescue, control of released hazardous materials, damage evaluation, and public safety to see how rehabilitation could reduce post-earthquake demands for their services.

As a collateral benefit, share the information already collected to help these local officials understand their responsibilities and likely problems after an earthquake, use the information derived from these consultations to define problems that can be reduced through seismic rehabilitation, and encourage revision of the emergency response and recovery plans using the information collected.

Identify redevelopment project areas (and funding sources) and consider formation of new projects, possibly expanding the definition of "blight" to include potentially earthquake-vulnerable buildings.

Outline administrative implications including: potential demands for program management (resources and skills); need to support and coordinate proponent activity; need for enhanced enforcement capability (design review and construction inspection); cost of inventories and engineering, economic, social and environmental impact data collection and analysis; cost to support stakeholder participation; cost to implement alternative programs; length of time needed to adopt a program and the approximate duration of the implementation phase; and estimated cost in lost revenues, additional staff requirements, and additional capital outlay to the local government or company.

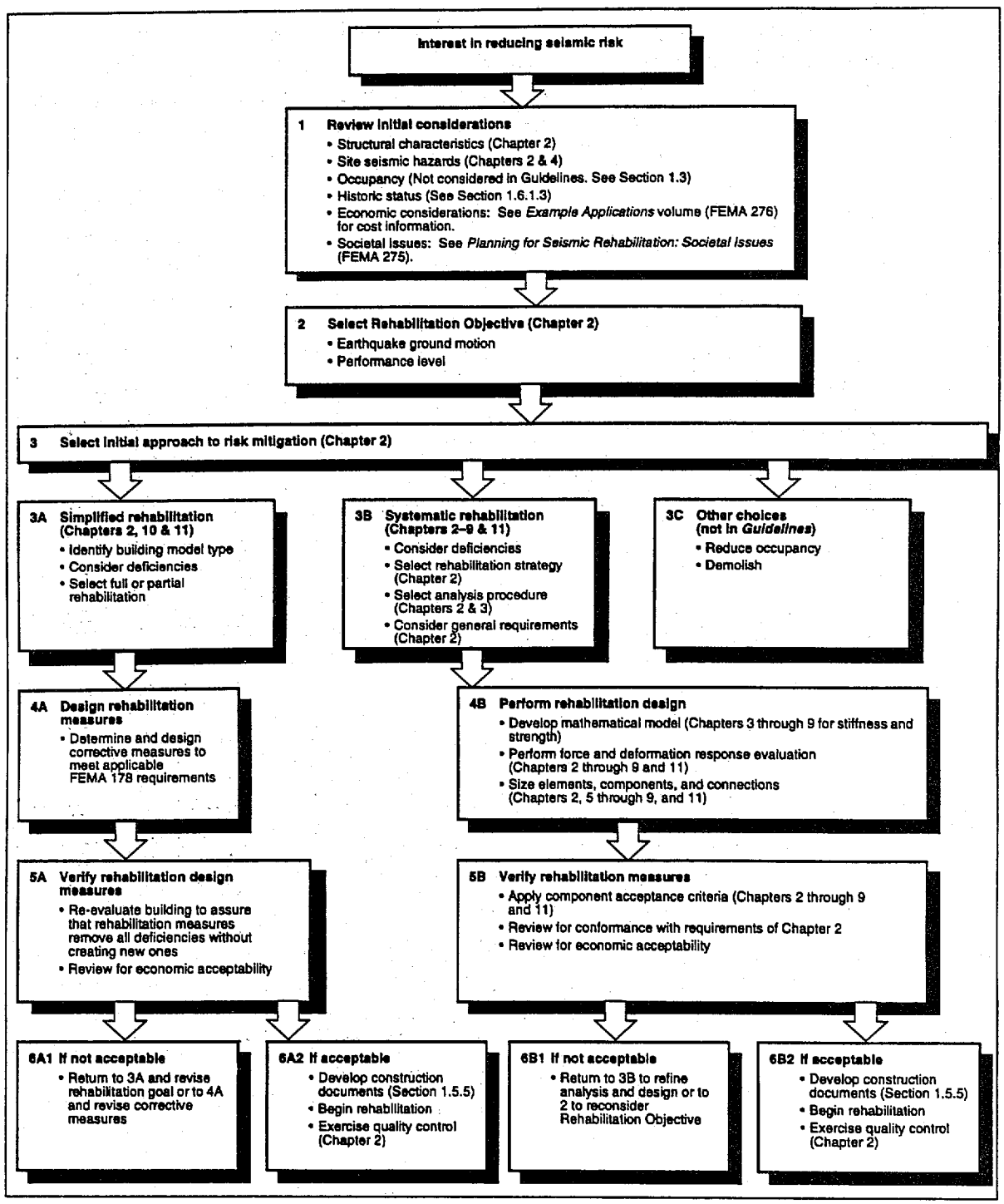

FIGURE A1 Rehabilitation process flowchart
(from Chapter 1, *NEHRP Guidelines for the Seismic Rehabilitation of Buildings*.

Consult legal counsel on the adoption and implementation processes, potential impacts on property rights and leases, and the need to disclose risk information.

Estimate total costs including: cost of engineering and rehabilitation, cost of required other work (ADA compliance, code upgrades), cost of alternative temporary space and relocation, costs of disruption (estimated), possible effect on leases and possible loss of tenants, lost rent and sales during the period of disruption, loss of sales tax revenues, increased debt service for the owner, and increased rent because of the cost of rehabilitation and disruption.

Describe effects that are not quantifiable solely as monetary costs such as loss of housing stock, loss of historical and architecturally important buildings, and business failures, closures and relocations.

Describe trade-off values (amount and cost [direct and indirect]) versus benefits (even if vague, abstract, or probabilistic). The potential bases for justifying seismic rehabilitation include the following:

- Fewer lives lost
- Fewer persons injured
- Less property damage
- Less demand for emergency response
- Less loss of housing resources
- Less loss of historical resources
- Faster economic and social recovery
- Less financial impact of earthquakes
- Less business downtime
- Increased safety for customers/tenants
- Less change for the neighborhood
- Increased building value
- Higher market value for buildings
- Less costly insurance premiums
- More secure equity for loans

Identify existing groups that will be affected by or interested in the seismic rehabilitation program:

- Homeowners associations
- Chambers of commerce
- Merchants associations
- Building and owners managers associations
- Boards of realtors
- Historical and preservation societies
- Ethnic business associations and groups
- Tenant organizations
- Community service clubs
- Labor unions and employee associations
- Civic, religious, fraternal, and other groups

Identify potentially affected autonomous political entities including redevelopment agencies and special districts (fire, police, school, water supply, sanitary, gas, electric and recreation).

Identify expert groups with knowledge to add to the considerations. Some of these groups include:

- Architects
- Civil engineers
- Engineering geologists
- Structural engineers
- Attorneys
- Certified public accountants
- Bankers and financial planners
- Insurers and reinsurers
- University faculties
- Realtors and property managers

Identify those groups directly affected by decisions may not have an effective way to participate in the decision-making process including low income residents of affected buildings, homeless persons, minorities and those with language limitations, elderly and retired persons, and physically challenged persons.

Determine if new organizations are needed to represent previously unorganized groups of affected persons, specific concerns, or issues. If so, identify possible leaders and members to facilitate the formation or representation of the group(s).

Identify potential proponent and opponent leaders, including their respective positions.

Identify news media and meet with reporters and editors to brief them on the concerns and the adoption process, provide background information, and commit to a relationship based on open communication. Media outlets include general circulation daily and weekly papers, ethnic papers, business and legal papers, radio news, television news, and community focused magazines.

Learn how to communicate matters of seismic risk, impacts, conflicting values, and uncertainty to an audience that may not understand the language of science and engineering and may very well have differing values on risk acceptance and the cost of risk reduction.

Accept the idea that people and groups view risk differently and have different values when balancing earthquake risk with other values.

Realize that a mathematical description of risk does not convey a complete message to most people. In addition to describing the probability or chance of an earthquake of a certain magnitude within a year, 30 years or a 100 years, describe what may happen in terms of the damage and the consequences of that damage to a building or the community.

Communicate facts, avoid the temptation to hide impacts or express judgment of others' values, and avoid surprising other participants with information that implies a "hidden agenda."

Deal immediately with concerns raised (even rumors) and solicit expert assistance to address issues and concerns directly.

Provide information on earthquake risk and building vulnerability from trustworthy sources (leaders, officials, expert agencies, professional associations, university faculties).

Provide references where interested parties may obtain more information.

Reconsider loss estimation studies done in Step 1A using new data or, if not done, consider performing these analyses at this point.

Decide whether the seismic risk to the community, company, or owner is significant and whether or not to proceed to Step 2.

Step 2: Develop and Revine Alternatives

Assuming the earthquake hazard and community vulnerability combine to create a seismic risk justifying seismic rehabilitation of certain buildings, Step 2 will result in the definition of practical alternatives. Simply stated, no standard formula or approach will work everywhere. While information already collected may suffice, it often is essential to collect more detailed data (e.g., a property-by-property inventory or consultant analyses of specific issues).

More precise data on the community building stock and its general earthquake-resistance characteristics are almost always needed because many Step 2 discussions of alternative approaches revolve around the performance levels desired for various types of buildings (and therefore the costs) and the number of buildings potentially involved.

Develop a strategy and a process that will address concerns and involve affected organizations in discussions of alternatives, within the limits posed by available resources and in a reasonable period of time.

Meet with building owners and hear concerns, be open to new or unexpected alternatives, and respect different perceptions.

Provide information to interested individuals and groups on the objectives of possible rehabilitation programs, the seismic hazards, building vulnerability, and the consequences of earthquake damage if nothing is done.

Solicit involvement, comments and suggestions from interested individuals and groups, respond to comments and suggestions, and use informal as well as formal meetings.

Consider formation of an advisory committee and evaluate potential chairs. For the chair, look for a person known for openness and objectivity who is experienced at running meetings, willing to find common ground and build consensus rather than highlight differences and polarize, free from conflict of interest, able to devote the considerable time and energy required, and willing to recommend, support and defend tough decisions and recommendations -- often in public forums.

Regularly meet with and brief council members, corporate decision-makers, or clients on the development of alternatives.

Provide photos of typical and relevant damage and provide documentation of possible damage to the community or company.

Show proof of the seismic hazard.

Describe the possible consequences of likely earthquake damage, both direct (damage to buildings and injuries) and indirect (disruption, loss of tax revenues, loss of housing and historical resources).

Explain the scope and cost of alternative approaches.

Propose an implementation program such as one of the following model programs or a hybrid that combines elements of other models: attrition process, voluntary program, informal/encouragement program, and mandatory program.

Decide which of the building types and uses described above to include.

Decide which neighborhood or geographic areas to include.

Determine if existing plans to upgrade facilities or redevelop an area can be amended to incorporate seismic rehabilitation of buildings.

Decide on a process to enforce the regulations including scopes and deadlines for reports, applications, and work and consider penalties for noncompliance including the possibility of condemnation and demolition.

Reconsider the desired seismic rehabilitation performance levels discussed above according to uses and building types selected in the Step 1A. Decide if it is still feasible to meet those levels in light of the costs, and revisit the performance levels to determine if they are too low to provide the benefits desired or possibly unnecessarily high.

Perform benefit-cost analyses. Because of the difficulty in quantifying the costs and benefits of seismic rehabilitation programs, the low probability of damaging earthquakes and the unpredictability and infrequency but high-consequence of these events, the benefit-cost ratio will often appear unfavorable at first. However, it may not be so when the value of life is taken into account. Nonetheless, the benefit-cost analysis is a good tool to compare alternatives and provides a place to start when considering possibilities to improve the ratio. To this end, consider the following incentives to make seismic rehabilitation less costly and less disruptive to those affected:

- Use preservation tax incentives for historic buildings
- Waive permit and inspection fees
- Waive planning requirements (off-street parking, density restrictions, variance request procedures
- Provide guidance and no-cost inspection services for "do-it-yourself" homeowners
- Allow property tax adjustments and other tax incentives
- Offer loans backed by government bonds
- Form a "Redevelopment Area" and "build-in" seismic rehabilitation
- Use "conservation corps" personnel for some of the work (especially for elderly and low-income residents)
- Increase availability of special purpose construction loans
- Encourage bank/lending institutions to provide incentives
- Secure insurance premium reductions

Solicit comments and advice from the affected parties, their organizations, and the involved professional organizations.

Consider a variety of management solutions that vary with the types of buildings covered by the program (performance objectives, length of time for implementation, triggers, level of building department involvement, incentives).

Decide how long owners should be protected from any new retroactive requirements.

Identify actions to mitigate non-financial impacts of the program.

Determine if and how tenant relocation costs may be funded.

Outline special considerations for historical buildings.

Determine criteria and processes for time extensions.

Revisit the benefits of avoiding future losses, the costs of doing nothing, and the costs of the rehabilitation program selected.

Assess the political feasibility of various options and ask two key questions: Is there enough information and sufficient support to push for action? Is an interim decision or a phased decision-making process appropriate?

Recognize likely pressure to delay action if an earthquake is not perceived as imminent, but recognize pressure to act quickly after an earthquake when repairs and possibilities for rehabilitation are suddenly salient to decision-makers.

Review the strategies available (attrition, voluntary, informal/encouragement, or mandatory) and formulate a recommendation.

Step 3: Adopt an Approach and Implementation Strategy

Once a recommendation to rehabilitate earthquake-vulnerable buildings has been forwarded to the final decision-maker(s), for public agency programs an even more public process begins. A seismic rehabilitation advocate must understand that the decision-maker(s) are expected to request both pro and con information and balance the many needs and capabilities of the community, corporation, or owner. Step 3 uses the results from previous steps to provide the expected information.

Explain the seismic risk and support it with expert testimony.

Determine if seismic rehabilitation can be incorporated into other community programs to improve or redevelop specific areas or facilities.

Explain the benefits, costs, and unquantifiable effects.

Explain the views of those affected.

Explain the reasons for the recommended program in comparison to other possible alternatives.

Anticipate and prepare answers for the following questions: How much will it cost (our city, our company) to comply with the proposed program? How much time do we/I have to make this decision? What is the liability associated with going ahead, or doing nothing? Is there a real earthquake hazard affecting this area? Are standards for seismic rehabilitation available? How can we/I justify imposing this measure (to constituents, a board, a boss, or a client)? What will happen (to the community, business, building or client) if nothing is done? What are neighboring jurisdictions (or competitors) doing?

Recommend and participate in formal hearings.

Modify the recommended program to meet any concerns and to address new information raised during hearings or the formal decision-making process.

Step 4: Secure Resources and Implement

Seismic rehabilitation programs do not run without resources and problems. Their execution requires that resources be committed, processes established, materials prepared, monitoring and evaluations carried out, and adjustments made. Owners of earthquake-vulnerable buildings are seldom well financed, often have difficulty securing new loans, and usually are not experienced in hiring engineers or managing complex construction projects, especially ones that affect other community interests. Step 4 recommends anticipating these conditions.

Obtain funding, qualified staff, office space, equipment, and, if necessary, consultant support.

Prepare and disseminate materials oriented toward all affected parties.

Establish a process for monitoring rehabilitation program progress, identifying problems, and reporting results.

Maintain contact with the organizations and individuals involved with developing the alternatives and adopting the program. Hold meetings with affected groups to facilitate open communications.

Maintain quality control to ensure that projects are properly designed and executed.

In order to protect the credibility of the program, maintain vigilance for over-charging or other fraudulent business practices or incompetent work by engineers, architects, and contractors.

Work with and supply information to building owners to assist them in the wise selection of engineers, architects, and contractors.

Ensure that projects meet requirements to mitigate community impacts.

Be sure that those responsible for offering and managing incentives are responsive to owner needs.

Amend technical provisions of the program whenever the engineering-oriented Guidelines documents are amended.

Be prepared to move quickly if unacceptable or unanticipated side effects occur to avoid creating a political backlash caused by the normal inability to see absolutely every problem ahead of time.

Encourage professional organizations, local colleges, and others to offer training for architects, engineers, plan checkers, inspectors, and construction professionals on following and implementing the Guidelines and their proper execution.

Expect the program to be dynamic and in need of further refinements as a result of experience gained during implementation.

Recommend program refinements to decision-makers when needed.

CONCERNS UNIQUE TO USERS

Depending upon the user (jurisdiction with building code enforcement authority, private or corporate owner, consultant) and the intended application of the *Guidelines*, differing perspectives and problems must be taken into account.

Local Government Building Official Tasks

Design, recommend, advocate, and then implement a seismic rehabilitation program for certain types of building within the jurisdiction. Serve as responsible staff person on the many aspects of the program: seismic risk, engineering, administrative, and possibly even socioeconomic and policy.

Learn what other communities are doing and cooperate to share resources.

Although usually licensed by the state, assess the earthquake engineering capability of local design professionals and contractors to carry out the actual seismic rehabilitation of buildings.

Assess the capability of the building department staff and determine appropriate training needed and its cost.

Self-Motivated Owner Tasks

Recommend to management alternatives for addressing seismic risk.

Locate and engage knowledgeable professionals: geologists and geotechnical engineers, structural engineers, and mechanical/electrical/process engineers.

Consider prior rehabilitation experience and experience using the *Guidelines*.

Consider how to evaluate both single buildings and groups of potentially vulnerable buildings.

Determine the relative importance of various buildings to the company.

Consider building(s) occupancy and functions.

Consider corporate image and reputation with customers and suppliers.

Ensure post-disaster business resumption plans are updated.

Consider post-earthquake access to suppliers, customers, and employees.

Determine geographic distribution of the hazard and the probability of seismic events by region. Quantify the expected seismic loads and determine resulting building vulnerabilities (expected performance under specified loads).

Determine the planning horizon.

Conduct a rapid assessment of buildings.

Determine performance objectives for the company, lines of business and specific facilities.

Do a comparative risk evaluation of facilities considering hazard, vulnerability, and importance.

Determine the seismic rehabilitation requirements, if any, of the jurisdictions responsible for building safety.

Determine availability of external financial incentives.

Determine penalties, if any, for not performing rehabilitation.

Determine if local building or planning regulations will require compliance with other health and safety, access, hazardous material, energy conservation, or historical requirements for each of the buildings found to be vulnerable.

Determine the cost of permits, steps involved, and time requirements to rehabilitate each vulnerable building.

Consider how to benefit from community, customer, and client good will earned by rehabilitating buildings, and determine how to capitalize on these benefits.

Determine if uses and functions at risk are critical, or if redundant facilities provide the necessary back-up at locations outside of the same hazard area.

Determine alternative strategies for meeting desired performance objectives. Have the design consultants do conceptual designs for the following: short-term, temporary measures such as shoring collapse-hazard building elements; nonstructural and falling hazard abatement measures to remove the most vulnerable life-threatening elements; and permanent rehabilitation measures consistent with performance objectives

Identify and meet with persons responsible for the following: operations and business resumption, space management, risk management (including insurance and hazardous materials), emergency response and employee safety, legal counsel, finance, public relations, and government relations.

Survey vacancy rates in nearby buildings to determine the cost and feasibility of temporarily relocating functions during rehabilitation.

Determine knowledge and level of commitment of the upper management and Board of Directors.

Determine responsibility of corporate officers, fiduciary responsibility for the corporation, and personal liability.

Determine the status and flexibility of capital replacement schedules and facility obsolescence.

Review short- and long-term use plans for each building.

Consider competing needs for funds including pressure for short-term profits versus long-term protection of assets, including equipment, buildings, inventory.

Describe the consequences of damage including: business interruption; vulnerability to temporary and permanent loss of market share; reputation for reliability; loss of employees to undamaged competitors; injury to employees; political ramifications, especially if a major local employer or multiple residential or commercial property owner; liability for injuries; off-site consequences of release of hazardous materials; and cost of repairs.

Secure lease or purchase options on alternative space before announcing a need for relocating functions from vulnerable buildings.

Meet with employees and tenants to explain the risk and the steps being taken to address it.

Meet with community groups and local government officials as appropriate.

Evaluate the company's in-house emergency response capability and local government's capability to respond to company problems.

Do a benefit-cost analysis and include a qualitative description of the intangible matters relevant to the decision.

Consulting Design Professional Tasks

Provide professional services to a client seeking to reduce and manage the seismic risk to his or her facilities.

Determine the owner's concerns and objectives and which facilities are involved.

Ask how will priorities be established (risk, occupancy, function, vulnerability, or other factors).

Determine desired performance objectives (which very well may change after risk information and the cost of rehabilitation alternatives are known).

Determine whether risk management measures, (e.g., emergency response and business resumption plans), can be considered as alternatives.

Be certain that the owner understands the possible nonengineering issues, (e.g., relocation, business interruption, costs).

Determine who is responsible for each point under "Self-Motivated Owner" section above.

Secure the engineering and risk management know-how if it does not exist.

Outline any required internal training.

Hire subcontractor specialists.

Determine how knowledge of risk will affect the liability of the firm and client.

Determine how designing to the client's performance objectives using the *Guidelines* will affect your liability.